

Genetic evaluations based on data from automatic milking systems

B. Heringstad^{1,2} & H. Kjøren Bugten¹

¹Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, P. O. Box 5003, N-1432 Ås, Norway.

²Geno Breeding and A. I. Association, Ås, Norway.

Abstract

Norwegian dairy farming is changing towards larger herds with automatic milking systems (AMS). Today about 1/3 of the dairy cows are in AMS herds. Vast amounts of data, objective, frequent and accurate measures of many important traits, are recorded routinely in AMS and research is needed to find how we best can make use of these data for genetic evaluation. The aim of this first genetic analysis of Norwegian AMS data was to estimate heritability and predict breeding values for milkability in Norwegian Red. The data came from 46 herds with DeLaval milking robots. The final data set had 1.6 million daily records, from 8,134 lactations of 4,835 Norwegian Red cows. Milkability was defined as average milk yield per total time spent in the milking robot (kg milk per minute “box time”). The average milkability was 1.5 kg milk per minute box time, and 95 % were within the interval 0.7 – 3.3. Estimated heritability of was 0.11 for daily milkability, 0.30 for mean of day 30-60, and 0.29 for lactation mean milkability. This is higher than the heritability used in the current routine genetic evaluation for Norwegian Red which is based on milking speed scored by the farmer in 3 categories (slow, medium, fast). Estimated breeding values (EBV) for milkability, expressed in kg milk per minute box time, varied from -0.40 to 0.47. More precise phenotypes give higher heritability and more accurate breeding values.

Keywords: automatic milking system, milkability, new traits, genetic evaluation

Introduction

The number of dairy herds with automatic milking systems (AMS) is increasing rapidly in Norway. Today about 1/3 of the dairy cows are in AMS herds, and this will within a few years be the dominating dairy production system in Norway. Increased herd size and AMS represent new possibilities and challenges also related to breeding. Having a large proportion of the dairy cow population in AMS, facilitates use of these data for genetic evaluation. AMS provides objective, frequent and accurate measurements, from which it is possible to define new traits that can be implemented to improve the breeding program and select cows that fit better in AMS.

So far there have been few genetic studies based on AMS data. Byskov et al. (2010) estimated genetic parameters for udder conformation (teat coordinates) and milking speed and found higher heritability for objectively measured AMS traits than for the corresponding subjectively scored traits currently used for genetic evaluation. König et al. (2006) concluded that milking frequency could be a potential behavior trait to include in the breeding program. Rinell (2013) found moderate high genetic correlations between traditional temperament score and teat cup kick-off traits from AMS, suggesting that data from AMS could provide objective measures of cow temperament or behavior. Carlström et al. (2013) estimated genetic parameters for milk flow rate, box time, milking interval and number of milkings per day,

based on AMS data from about 5000 cows, and concluded that AMS data from commercial herds are useful for genetic analyses of milkability traits.

Vast amounts of data are recorded routinely in AMS, and research is needed to find how we best can make use of these data for genetic evaluation. The main aim of this first genetic analysis of Norwegian AMS data was to estimate heritability and predict breeding values for milkability in Norwegian Red.

Material and methods

The analyzed data were from 46 herds with DeLaval milking robots. From each herd data from at least 2 years were extracted, and the dataset had information from about 6000 cows, and included more than 2 million daily records. Details regarding data collection and editing are given by Bugten (2013). Records from 6 to 305 days after calving, from lactation 1-7, from daughters of Norwegian Red A.I. sires were kept for analyses. The final data set had 1.6 million daily records, from 8,134 lactations of 4,835 Norwegian Red cows. A pedigree file with 44,403 animals was built by tracing pedigree of cows with records back as far as possible.

Milkability. Milkability was defined as average milk yield per total time spent in the milking robot; i.e. kg milk per minute “box time”. In addition to the actual milking time box time includes the time used for preparation and attachment of teat cups, as well as the time the cow uses before she decide to leave the robot. This is a combined measure of milk flow/milking speed and how efficient the cow is when visiting the milking unit, thus directly associated with the capacity of the milking robot. Figure 1 shows the variation in daily average milk yield per minute box time. The overall mean was 1.5 kg milk per minute spent in the robot, and 95 % were within the interval 0.7 – 3.3.

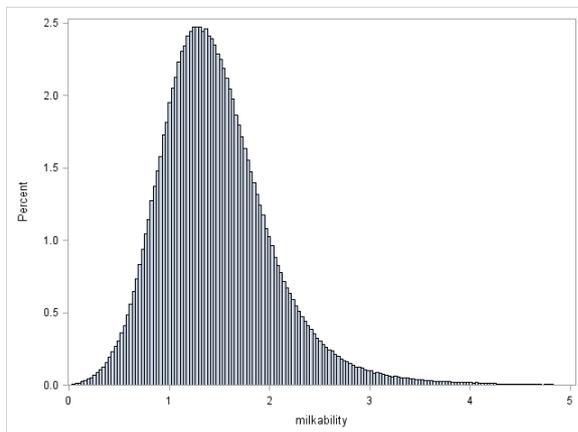


Figure 1. Distribution of daily average milk yield per minute box time.

Trait definition. Three trait definitions were compared; daily milkability, mean milkability from day 30 to 60, and lactation mean milkability from day 6 to 305. Summary statistics of the analyzed traits are given in Table 1. A minimum of 5 daily records were required to be included in the mean milkability traits.

Factors affecting milkability. Milkability varied with days in milk (DIM); were low in early lactation, increased towards top lactation, and decreased thereafter somewhat as the milk yield decreased towards the end of lactation. First lactation cows were on average slower than

older cows, especially in early lactation. Other factors affecting milkability were herd, year and season, milking frequency, and milk yield. Higher milk yield is associated with faster milking speed (kg/min). Box time will also be affected of the cows behavior, e.g. if she stands still while being milked, kick off the milking unit, and how fast she will leave the robot after milking.

Table 1. Summary statistics of milkability traits (kg milk per minute box time).

	Daily	Mean d 30-60	Lactation mean
No of observations	1,597,156	6,808	8,046
No of cows	4,835	4,264	4,787
Milkability, mean kg milk/min box-time	1.47	1.48	1.44

Model. Milkability traits were assumed to be the same trait across lactations and analyzed with repeatability models. The univariate linear animal models included fixed effects of herd-year, month-year of calving, age at calving by lactation number, and random effects of animal and permanent environment. The model for daily milkability had in addition an effect of DIM. Variance components were estimated using DMUAI in the DMU software (Madsen & Jensen, 2007).

Results and discussion

Heritability. Estimated variance components for the 3 traits are given in Table 2. The heritability of milkability (average kg milk per minute box time) was 0.11 for daily-, 0.30 for mean of day 30-60, and 0.29 for lactation mean milkability. These heritability estimates were lower than in some previous studies of related traits based on AMS data. Carlström et al. (2013) reported heritabilities of 0.37-0.48 for average flow rate and 0.38-0.44 for box time for Swedish Red. Byskov et al (2012) estimated a heritability of 0.63 for milk flow in Danish Holsteins. The heritability of the two traits based on mean values (0.29 and 0.30) were higher than the heritability currently used in the routine genetic evaluation of milking speed for Norwegian Red (0.19), which is based on milking speed scored by the farmer in 3 categories (slow, medium, fast) (Geno, 2014). More precise phenotypes give higher heritability and more accurate breeding values.

Table 2. Estimated variance components, with their standard error (SE) and the corresponding heritability and repeatability of daily-, mean day 30-60 -, and lactation mean milkability.

Variance component	Milkability trait (kg milk per minute box time)		
	Daily	Mean day 30-60	Lactation mean
Animal	0.033 (0.004)	0.037 (0.005)	0.033 (0.004)
Permanent environment	0.073 (0.004)	0.050 (0.004)	0.046 (0.004)
Residual	0.198 (0.0002)	0.038 (0.001)	0.035 (0.001)
Heritability	0.11	0.30	0.29
Repeatability	0.35	0.70	0.69

Breeding values. Figure 2 show the distributions of estimated breeding values (EBV) for milkability (day 30-60) for cows with data (4264 cows) and AI sires with daughters in the dataset (775 bulls). EBV, expressed in kg milk per minute box time, varied from -0.40 to 0.47. The genetic difference between the cow with the highest and lowest EBV is equivalent to 0.87 kg more milk per min box time. The rank correlation between EBV for daily milkability and EBV for lactation mean milkability was 0.98, while the rank correlation to EBV for mean milkability from 30-60 day were 0.87 (daily) and 0.88 (lactation mean).

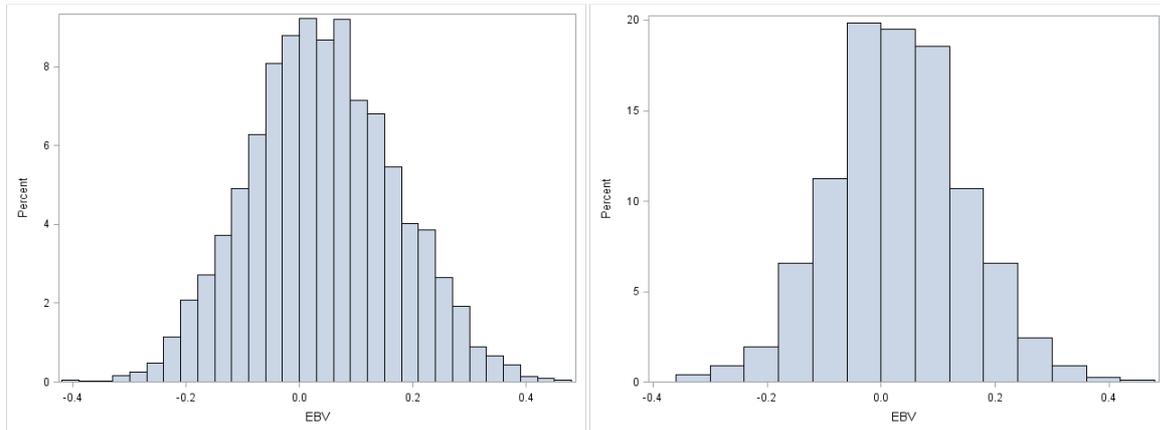


Figure 2. Distribution of estimated breeding values (EBV) for milkability (day 30-60), kg milk per minute box time, for cows with data (left panel) and AI sires with daughters in the dataset (right panel).

Trait. Milkability defined as milk yield per total time spent in the milking robot is directly associated with the capacity of the milking robot, and may be an interesting trait if the objective is to breed more efficient cows for AMS. This is a combined measure of milking speed and aspects of cow behavior. Genetic improvement of milkability would be beneficial also in other production systems.

Possibilities and challenges. The cows meet different challenges in the environment in the AMS herds, and the breeding program should be adjusted accordingly with respect to traits, trait definitions and weights in the total merit index. There are many measurements related to milking (e.g. box-time, no of kick offs, milk flow) and cow traffic (e.g. milking frequency) routinely recorded in AMS that can be used to define new behavior and milking efficiency traits.

Conclusion

Results show that data from AMS can be used for genetic evaluations. Data routinely recorded in AMS provide information on new traits that can supplement or replace current traits in genetic evaluation.

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List of References

- Bugten, H. K., 2013. Bruk av utmelkingsdata fra mjølkerobot i avlsarbeidet. Master thesis Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences, Ås, Norway.
- Byskov, K., L. H. Buch & G. P. Aamand, 2012. Possibilities of implementing measures from Automatic Milking Systems in routine evaluations of udder conformation and milking speed. *Interbull Bulletin*, 46: 28-32.
- Carlström, C., G. Pettersson, K. Johansson, E. Strandberg, H. Stålhammar & J. Philipsson, 2013. Feasibility of using milkability data from commercial automatic milking systems for genetic analysis. *J. Dairy Sci.* 96: 5324-5332.
- Geno, 2014, Egenskapene i avlsmålet. Utmelking.
<http://www.geno.no/Start/Avl/Avlsmal/Egenskapene-i-avlsmalet/Utmelking/?parent=317>
- König, S., F. Köhn, K. Kuwan, H. Simianer & M. Gaulty, 2006. Use of repeated measures analysis for evaluation of genetic background of dairy cattle behavior in automatic milking systems. *J. Dairy Sci.* 89:3636–3644.
- Madsen, P. & J. Jensen, 2007. A User's Guide to DMU, A Package for analyzing multivariate mixed models. Version 6, release 4.7. University of Aarhus, Faculty Agricultural Sciences, Dept. of Genetics and Biotechnology, Research Centre Foulum, Denmark
- Rinell, E., 2013. A genetic analysis of traits recorded by automatic milking systems - the possibility for a new method to evaluate temperament of dairy cows. Master thesis Swedish University of Agricultural Sciences & Norwegian University of Life Sciences.